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<p>(54) Title: METHOD AND DEVICE FOR, AND USE OF, A DENTAL PRODUCT OR OTHER PRODUCT FOR THE HUMAN BODY</p>		
<p>(57) Abstract</p> <p>A dental product is produced from material in powder form. In a first manufacturing stage, the product is given a shape which is larger than its final shape, and in further manufacturing stages the product is subjected to material shrinkage/sintering and working in order to obtain the final shape. Metal powder is applied to the mould tool, and the mould tool with the applied metal powder is placed in pressure-generating equipment (6) where the powder (1') applied to the mould tool (2d) is subjected to compaction pressure (F) which compacts the powder so that at least an 80 percent basic density is obtained in the material. The compacted material is then machined and, after machining, it is removed from the mould tool. The sintering stage is then carried out so that the final shape is obtained.</p> <div data-bbox="779 1155 1234 1533"> </div>		

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## TITLE

Method and device for, and use of, a dental product or other product for the human body.

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## TECHNICAL FIELD

The present invention relates to a method for producing a dental product or other product for the human body using material in powder form. In a first manufacturing stage, with the aid of a mould tool, the product is given a shape which is larger than its final shape, and in further manufacturing stages the product is subjected to working and material shrinkage/ sintering to obtain the final shape. The invention also relates to a product intended as a component in a dental application or other application in the human body, where it cooperates with members in the form of implants, attachment parts for implants, bones, for example dentine, tooth remnants, etc. The product is made up from worked and sintered and worked powder material. The invention also relates to a use of the product of the said type.

## 25 PRIOR ART

It is already known to make products or bodies of the type in question using powder material in the form of ceramic powder. In this context, it is known to use mould tools in which the ceramic powder is applied. The mould tool is given a larger shape or size. The ceramic powder is applied in the mould and is exposed to compression forces, after which the compressed body is worked and shrunk further in a sintering process.

Reference may be made in entirely general terms to manufacturing principles which are proposed and used in the Procera technique for manufacturing products of the type in question and where, inter alia, final outer shapes are produced from enlarged outer shapes.

Thus, from United States Patent 5,192,173 (with the same inventor) it is already known to create a linearly enlarged shape on the tool in question. Reference is also made to European Patent 384,908 B1  
5 (same inventor) which shows that a linearly enlarged body can be subjected to a sintering process so as to be given its desired final shape.

It is also known to make products or bodies of the abovementioned type from metal. The outer shape of  
10 the product is in this case turned or milled from a blank. An electro-oxidation tool with an outer shape corresponding to the inner shape of the product is made and is used for producing the inner surface of the product by means of electro-oxidation.

15

## DISCLOSURE OF THE INVENTION

## TECHNICAL PROBLEM

The production of ceramic products and metal  
20 products has hitherto had to be carried out using two completely different techniques which have been employed within the technical area of dental technology and technology related to the human body. This has divided resources for manufacturers of these types of  
25 products and other products for the human body. There is a requirement for the technical resources to be brought together more effectively and, for example, for the same types of personnel to be used to produce caps, spacers, bridges, etc. The invention aims to solve this  
30 problem among others.

In the sector concerned with the manufacture of products, for example caps, made of metal material, consideration has been given to imitating the principles used for ceramic caps or equivalent.  
35 However, there has been strong technical opposition and considerable bias against its being possible, in serial manufacture of structurally robust caps/products which are to function in a technically severe environment (in the patient's mouth) and therefore must have strict

strength requirements and at the same time upholding the precision requirements, to be able to manufacture caps/products in the same way as in ceramic production.

5 The invention counters this strong technical opposition and bias and takes a completely new approach in order to permit a new type of manufacture of caps/products of the type in question.

10 There is a need to technically simplify, and to make less expensive, the previous manufacture of caps and other dental products using mechanical working and electro-oxidation. The invention solves this problem too and now proposes principles in which previous strength and precision requirements (0.2  $\mu\text{m}$ ) can also be maintained.

15 In connection with the new principles for production of caps/products made of metal, there is a need to be able to vary the strength requirements, precision requirements, manufacturing process, etc. The invention solves this set of problems too and is not  
20 confined to individual procedures for achieving the requirements set. The new principles are especially suited to titanium powder which has the best biocompatible character. However, there have been strong doubts as to whether it is in principle possible  
25 to make caps and similar products from titanium powder material.

#### SOLUTION

30 The feature which can principally be regarded as characterizing a method according to the invention is that metal powder is applied to the mould tool, and that the mould tool with the applied metal powder is placed in pressure-generating equipment where the  
35 powder applied to the mould tool is subjected to compaction pressure which compacts the powder so that at least an 80 percent basic density is obtained in the material, and that thereafter the material compacted on the mould is first machined and then removed from the

mould tool, after which the said material shrinkage/sintering stages are carried out so that the final shape is obtained, and at the same time a porosity of at most about 6 percent by volume, preferably at most 2 to 3 percent by volume, is obtained in the sintered product.

In one embodiment, the outer shape of the product is produced or worked (in an enlarged state), after which the product's final shape is obtained in the sintering process. The product is given a distinct or substantial homogeneity with respect to the distribution of the porosity. The material of the product is treated in such a way by the new method that it becomes ductile (substantially ductile) so that there is no tendency to crack or fracture under the effect of force.

In one proposed embodiment, the powder, on application to the mould tool in question, or stamp, is arranged in a powder-receiving unit in which the outer shape of the stamp can be lowered so that the powder surrounds the outer surface of the stamp. The powder can in this case be poured or applied into a tube-like or rubber bladder-like powder-receiving unit with elastic wall, which for example can be a silicone wall, via which the pressure is allowed to act in the pressure-generating equipment. The powder material chosen is preferably titanium powder which can comprise powder of the type TWC-f, whose particles are deformed by the compaction or the action of pressure in the pressure-generating equipment. The de-moulding of the compacted metal powder from the mould tool or stamp is preferably done in a bath of liquid nitrogen/air, and the stamp and the metal powder are in this case chosen with different coefficients of expansion, which means that the de-moulding is made considerably simpler. The sintering process is carried out in a vacuum sintering appliance.

In one embodiment, a number of mould tools or stamps which represent a number of possible unique or

individual inner shapes of the product are produced. The respective stamp is selected from a selection of stamps depending on the inner shape which the product is to be given.

5           The metal powder material compacted on the mould tool or stamp is machined by turning or milling, the mould tool/stamp being arranged together with the compacted material. The product can in this case be given a shape with a cap-like character where the inner  
10 shape of the product corresponds to the outer surface of the mould tool/stamp, and the outer shape of the product is machined, for example by turning or milling. The turning or milling is preferably carried out from the upper part of the cap-like product and working  
15 downwards.

          The mould tool/stamp is designed with a degree of enlargement which is preferably chosen within the range of enlargement immediately over 0% and up to about 12%, or immediately below 12%. The compaction  
20 pressure is chosen within the range of 300 to 900 MPa. The degree of enlargement used within the said range can be determined as a function of the compaction pressure used. The shrinkage or sintering operation provides a shrinkage or sintering which is slightly  
25 below the chosen degree of enlargement. The product is produced with inner or outer shapes produced with a degree of precision of about 20  $\mu\text{m}$ . The product is preferably a thin-walled product, with values within the range of 400 to 600  $\mu\text{m}$ . The product or the cap can  
30 also be produced with a precision which provides play of 100 to 400  $\mu\text{m}$  in relation to the opposing surface of the dental member in question or the dental component in question.

          Titanium powder is preferably used, but it is  
35 possible per se alternatively to use gold alloy or steel powder material.

          The new product can principally be regarded as being characterized by the fact that the powder material consists of or comprises metal powder material

deformed by compaction and sintered and having a porosity of at most 6, preferably 2 to 3, percent by volume.

The product is preferably (substantially) ductile and is (substantially) homogeneous and with evenly distributed porosity.

In a preferred embodiment, the product has essentially the shape of a cap. The product is thin-walled and can have a wall thickness or wall thicknesses within the range of 400 to 600  $\mu\text{m}$ . The product has a precision fit on its inner and/or outer shapes of about 20  $\mu\text{m}$ . The product or the cap forms a self-supporting structure or construction whose strength properties correspond to those of a conventional product for the dental application or other application in the human body. The product or the cap preferably has a degree of compaction which allows it to be worked by cutting tools, for example turning or milling, when producing the outer shape. The product consists or is made of titanium powder material in the first instance, although gold alloy or steel powder can alternatively be used.

A use of the product of the said type is characterized by the fact that metal powder which is compacted and sintered to a porosity of at most 6, preferably 2 to 3, percent by volume is used as powder material. Titanium powder is preferably used for producing a self-supporting product, for example cap.

30

#### ADVANTAGES

A surprising effect is that the strict precision requirements in accordance with the present case can be obtained with such a considerable degree of sintering of the metal powder, especially titanium powder, in question here.

The features which have been proposed above permit a considerably simplified manufacture of metal caps and products for dental application. Conventional



press moulding and de-moulding principles as well as sintering principles can be used, so that technically simple and well - proven operations are possible. Tests carried out with respect to strength and precision show  
5 surprising effects in that the cap/product can be made at least as strong and accurately as caps/products produced using conventional techniques and by conventional methods. In addition, it is possible to control the manufacturing process so that discoloring  
10 of the product's surface(s) is eliminated. Particular advantages of the invention are obtained when titanium powder is used. Titanium powder can give strong, load-bearing products or caps.

#### 15 DESCRIPTION OF THE FIGURES

A presently proposed embodiment of a method, device and use of the invention will be described below with reference to the attached drawings, in which

20 Figure 1 is a diagrammatic representation of the titanium powder used,

Figure 2 shows side views of parts of stamps which are included in a selection of stamps or tools,

Figure 3 shows in a perspective view, obliquely  
25 from above, a stamp chosen from the selection according to Figure 2 and applied in powder according to Figure 1, which powder is applied in a tube-shaped container,

Figure 4 is a perspective and diagrammatic representation of the components according to Figure 3  
30 introduced into compaction equipment,

Figure 5 is a perspective view of compacted powder adhering to the stamp in question, removed from the equipment according to Figure 4, the container according to Figure 3 being separated from the stamp  
35 and the compacted powder,

Figure 6 is a diagrammatic representation of the powder body and the stamp alongside or in machining equipment which is intended to give the metal powder body its outer shape,

Figure 7 is a diagrammatic side view showing the de-moulding function for the stamp and the worked powder body,

Figure 8 is a diagrammatic side view showing the worked powder body placed in a sintering oven,

Figure 9 shows, in a side view, an example of a structural design of a product/cap,

Figures 10, 11 and 12 show, in different perspectives, three different caps produced according to the new method.

#### DETAILED EMBODIMENT

Figure 1 shows diagrammatically a metal powder 1 which in the present case is a titanium powder, for example of the type TWC-f (Teledyn Wah Chang, where f stands for "fine") HDH 270 Mesh with a particle size of 53  $\mu$ m. The powder is a so-called coarse powder (not granular).

Figure 2 shows symbolically and partially a selection of mould tools 2, which are three in number and have been designated 2a, 2b, 2c. It is possible to have more stamps in the selection. Each stamp has a unique or individual outer shape 2a', 2b', 2c'. The surface of each stamp tapers towards the free end 2a'', 2b'', 2c'' of the stamp.

Figure 3 shows a stamp 2d chosen from the selection 2 and having the same character as the other stamps, the outer surface having been designated by 2d' and the tip by 2d''. Figure 3 shows an elastic container 3 which has the shape of a tube-like unit or bladder which, in this example, is made of silicone. The container or bladder can be filled with powder 1' and the stamp 2d lowered into the powder (and/or the bladder with the powder can be pushed onto the stamp) with its said outer shape 2d', which is entirely surrounded by the powder. The transfer of the powder has been symbolized by 4 and the transfer of the stamp by 5 (Figures 1 and 2, respectively).

The stamp 2d and container 3 with powder 1' have been transferred to a heating oven 6 according to Figure 4. The combination of 2d and 3 is supported in the oven by support members 6, 6b. The oven is of a type known per se and can be a so-called ISOSTAT press which is sold commercially. It is possible per se to use a special press which gives high pressures. The pressure in the press can in one embodiment vary from 300 MPa and upwards, for example to 900 MPa or more, and in each case a working pressure is assumed which is to be used for the product in question. As an example, the work pressure has been chosen at 320 MPa. The pressure used means that the powder 1' in the container 3 is pressed against the outer surface 2d' of the tool or stamp by virtue of the elastic wall of the container 3, the press forces being indicated by arrows F in Figure 4. The pressure can alternatively be exerted in one, two or more cycles. The pressure can be successively increased over a certain period of time. The pressure can be allowed to act on the powder for a predetermined period of time, for example 15 minutes. The pressure means that the powder is compacted to form a powder body in which powder particles or corresponding units are compacted in such a way that the particles or units are deformed. The powder body is pressed with great force against the outer surface 2d' of the stamp and comes to form a common unit with the stamp. The combination of 1', 2d and 3 can in turn be enclosed in a rubber covering (not shown) in order for the powder to be held in place. The covering can be a rubber balloon. The pressure treatment or compaction of the powder body means that it is possible to choose a basic density of the powder material of between about 80% and about 90%, or a porosity of between about 10 and 20 percent by volume.

According to Figure 5, the compacted powder body 1'' with attached stamp and container (or balloon) 3 is removed from the oven 6. The container 3 or

remains thereof (the balloon) are removed from the powder body in the direction of arrow 7.

Figure 6 shows a machining stage for producing and/or treating the outer shape of the powder body 1''.  
5 The machining equipment can be a turning lathe, milling device, etc., and has been symbolized by 8. The lathe bit or milling head 8a, 8a' has been shown in two positions. The machining preferably starts at the free/  
10 outer end 1a of the powder body and works downwards/inwards. This is done in order to achieve the best possible function and, for example, to prevent the cap from coming loose due to shiny and smooth surfaces in cooperation during machining. The particle size of the material of the stamp and cap can be included as  
15 parameters in the machining. The outer shape formed on the powder body 1' is controlled from a control function 9 which controls the machining equipment 8. The control function is already well known and will therefore not be described in detail here. Sharp edges  
20 and corners can also be milled or turned. Cooling agents, for example Medicway M15, are used during machining in order to prevent unwanted effects (discoloring) on the material in dry-milling or dry-turning.

25 Figure 7 shows the de-moulding function for the product 1''' which has been made and which, in the present case, has the form of a cap. In a preferred embodiment, the de-moulding is carried out using liquid nitrogen/air 10 in a container 11. The nitrogen/air is  
30 at a temperature of about -180°C. The stamp or tool 2d is in the present case made of material with a higher coefficient of expansion than the titanium/powder body. In this example, pure aluminium is chosen for the stamp/tool having a coefficient of expansion of  
35  $25 \times 10^{-6} \text{°C}^{-1}$ . The titanium has a coefficient of expansion of  $8.5 \times 10^{-6} \text{°C}^{-1}$ . This therefore means that the stamp 2d shrinks more than the powder body 1''' and that simple separation can take place. The separation function is symbolized by arrows 12, 13.

Figure 8 shows the shrinkage or sintering function for the enlarged shape 1''' for the product's final shape. The cap 1''' is applied in an oven 14 which is a vacuum oven in which sintering takes place and the cap 1'''' acquires its final shape. The temperature in the vacuum oven 14 can be chosen at, for example, between 800 and 1200°C, and the sintering is carried out in one or more cycles with predetermined times, for example times in the range of 2 to 4 hours/cycle. At the start of the sintering process, the temperature can be increased by 20°C per minute until the predetermined temperature is reached. The enlargement can be between values immediately above 0% to about or immediately below 12%. The cap 1''' is shrunk slightly less than the chosen enlargement. Thus, for example, a shrinkage of 6.2% may require an enlargement of 6.61%. The heat treatment/sintering means that the density further increases and can assume values of, for example, at least 94%, preferably 97 to 98%, which means a porosity of 6, preferably 2 to 3, percent by volume. A product is thus obtained made of sintered metal powder material and with the said low porosity. The product is preferably substantially homogeneous over its entire extent and is characterized by high ductility which prevents cracking and fracturing of the material when it is exposed to forces arising in the dental application or other application in the human body. Thus, for example, impact tests were carried out on the product obtained. Despite heavy hammer blows against the cap-like product, there was no tendency for cracks to form in the deformed area.

In a more detailed embodiment of the new method, an aluminium stamp is milled with the correct tooth shape or outer surface 2d' and is marked for re-positioning (see 2e in Figure 6) in order to facilitate the machining function. A silicone rubber mould is made or re-used and the aluminium stamp is entirely enclosed. In one embodiment, two silicone rubber mould parts are used so that the whole combination according

to Figure 3 for example is enclosed. Before this enclosing, titanium powder is filled into the rubber mould, cf. Figure 3. The aluminium stamp is pressed down (by hand) into the titanium powder and the second  
5 part of the rubber mould can then be applied so that the whole combination according to Figure 3 is enclosed. The combination of aluminium stamp, titanium powder and rubber mould 3 enclosed in the balloon or mould according to Figure 3 is placed in the press  
10 according to Figure 4, for example twice. By means of this, the titanium sits firmly on the aluminium stamp (which corresponds to the inner shape of the cap). The components are then removed from the oven 6 and the balloon and the rubber mould are removed from the metal  
15 body and the aluminium stamp. The aluminium stamp is re-positioned in the mill or turning lathe and the outer shape of the titanium cap is milled or lathed. The titanium cap is removed from the aluminium stamp in liquid nitrogen. The titanium cap can then thaw, and  
20 condensed water vapour evaporated off (dried). Penetrated cooling agent is released from the cap if this is necessary. The titanium cap is sintered on a molybdenum plate in vacuum with titanium (sacrificial titanium) present, which prevents discoloring. The  
25 titanium cap or equivalent product is then ready for inspection, measurement, shot-peening and continued working.

Figure 9 shows a product 15 according to the invention. The product is thin-walled and can have a  
30 wall thickness  $t$  of 400 to 600  $\mu\text{m}$ . In Figure 9, the cap is shown in relation to a member O, which can be a tooth remnant, an implant, an attachment part for the implant, dentine, etc. In Figure 9, the distance between the member and the inner surface 15b of the  
35 tooth cap is indicated by  $a$ . The cap 15 can be brought together with the member O so that a minimum gap arises, for example a gap of 100 to 400  $\mu\text{m}$ . When the cap has been applied on the member, the inner surface adjoins the outer surface of the member with an

intermediate gap. The outer surface 15a can in turn be adapted to a further component or components, for example in the form of a prosthetic construction.

Figure 10 shows a sintered cap 16 which has  
5 been produced in accordance with the above and which is made of titanium powder TWC-f, pressed in a CIP press (Cold Isolate Pressure) with 450 MPa and sintered at 1200°C for two hours. The surface structure is in this case chosen to be granular instead of smooth and the  
10 cap has a comparatively light (white) surface, which is important since it is not then necessary to conceal dark areas of the prosthesis. No brittle fractures or cracks occur. Figures 11 and 12 show two alternative embodiments of caps compared to the cap according to  
15 Figure 10.

In one use of the invention, the powder used for the production is a metal powder which on the one hand is compacted so that deformation of the powder particles or equivalent occurs and a high degree of  
20 basic density, for example 80%, is obtained and, on the other hand, is sintered so that shrinkage to the final shape and accuracy occurs, the degree of density increasing further, for example to about 94%, preferably 97 to 98%, which gives a porosity of about  
25 6, preferably 2 to 3, percent by volume. In a preferred embodiment, titanium powder is used.

The finished product obtained is preferably a cap with a cone-shaped or equivalent clearance which permits simple de-moulding in accordance with the  
30 above. Alternatively, a de-moulding method in the form of electro-oxidation can be used, which eliminates the stamp material.

As an alternative to titanium powder, it is possible to use powder of gold alloy, stainless steel,  
35 composite material of metal and/or ceramic powder. The pressure force, sintering time and sintering atmosphere can be adapted optimally to the different cases. The powder must have fine particles so that sintering can take place to the high density or low porosity. In

cases where de-moulding with cooling in liquid nitrogen in accordance with the above cannot be used, it is possible to use de-moulding based on mechanical removal.

- 5           The invention is not limited to the embodiment given above by way of example, and instead can be modified within the scope of the attached patent claims.



## PATENT CLAIMS

1. Method for producing a dental product or other  
5 product for the human body (1''''', 16, 17, 18) using  
material in powder form (1), where the product, in a  
first manufacturing stage, with the aid of a mould tool  
(2d), is given a shape (1''') which is larger than its  
10 final shape, and in further manufacturing stages is  
subjected to working and material shrinkage/sintering  
to obtain the final shape (1'''''), characterized in  
that metal powder (1') is applied to the mould tool, in  
that the mould tool with the applied metal powder (1')  
15 is placed in pressure-generating equipment (6) where  
the powder (1') applied to the mould tool (2d) is  
subjected to compaction pressure (F) which compacts the  
powder so that at least an 80 percent basic density is  
obtained in the material, and in that thereafter the  
20 material (1'') compacted on the mould is first machined  
and then removed from the mould tool, after which the  
said material shrinkage/sintering stages are carried  
out so that the final shape (1''''') is obtained and a  
porosity of at most about 6 percent by volume,  
preferably at most 2 to 3 percent by volume, is  
25 achieved.
2. Method according to Patent Claim 1,  
characterized in that during the working the outer  
shape of the product is worked or produced, and in that  
in the subsequent sintering stage the material is given  
30 the product's final shape and material properties.
3. Method according to Patent Claim 1 or 2,  
characterized in that the product material is given a  
homogeneous and ductile structure.
4. Method according to Patent Claim 1, 2 or 3,  
35 characterized in that the product's final shape and/or  
material properties are obtained using the Procera  
technique which is known per se.
5. Method according to any of the preceding patent  
claims, characterized in that the powder (1), when

applied to the mould tool (2d), here called stamp, is arranged in a powder-receiving unit (3) in which the outer shape (2d') of the stamp can be lowered so that the powder (1') surrounds the outer surface (2d') of the stamp.

6. Method according to any of the preceding patent claims, characterized in that the powder is poured or applied into a tube-like or rubber bladder-like powder-receiving unit (3) with elastic wall, for example wall made of silicone, via which the pressure (F) can act in the pressure-generating equipment (6), and in that the stamp, the unit and the powder are in turn enclosed in an elastic covering, for example rubber balloon.

7. Method according to any of the preceding patent claims, characterized in that the de-moulding is done in a bath (10) of liquid nitrogen/air, and in that the coefficient of expansion (thermal coefficient of expansion) of the mould tool/stamp exceeds the coefficient of expansion of the powder material (1''') so that the compacted material (1''') is given a release function from the mould tool/stamp (2d).

8. Method according to any of the preceding patent claims, characterized in that the sintering process chosen is vacuum sintering.

9. Method according to any of the preceding patent claims, characterized in that the material in powder form is selected from titanium powder composition (1), for example TWC-f with HDH 270 Mesh, 53 micrometres, whose particles or corresponding units are deformed by the action of pressure, and with particle sizes of 20 to 60 micrometres.

10. Method according to any of Patent Claims 1 to 8, characterized in that the metal powder consists of a gold alloy, for example MGA 001, with particle sizes of under 200 micrometres.

11. Method according to any of Patent Claims 1 to 8, characterized in that the metal powder is a steel powder, for example stainless steel powder with a particle size of under 20 micrometres.

12. Method according to any of the preceding patent claims, characterized in that a number of mould tools/stamps (2a, 2b, 2c, 2d) representing a number of possible inner shapes (2a', 2b', 2c', 2d', 15b) of the product are provided and in that the respective stamp is selected from among the said stamps depending on the inner shape which the product is to be given.
13. Method according to any of the preceding patent claims, characterized in that the material (1'') compacted on the mould tool/stamp in the compaction stage is machined by turning (8) or milling, the mould tool/stamp being arranged with attached compacted material.
14. Method according to any of the preceding patent claims, characterized in that the product is given a cap-like character where the inner shape of the product corresponds to the outer shape (2a', 2b', 2c', 2d') of the mould tool/stamp, and the outer shape of the product is machined by turning, milling, etc.
15. Method according to Patent Claim 14, characterized in that the turning or milling is carried out from the upper part (1a) of the cap-like product and working downwards.
16. Method according to any of the preceding patent claims, characterized in that the mould tool/stamp is designed with a degree of enlargement which is chosen within the range of enlargement immediately over 0% and up to or immediately below about 12%.
17. Method according to any of the preceding patent claims, characterized in that the compaction pressure is chosen within the range of 300 to 900 MPa.
18. Method according to any of the preceding patent claims, characterized in that the shrinkage/sintering is carried out in one, two or more cycles and/or in that when carrying out the shrinkage/sintering in the sintering equipment the temperature is increased a number of degrees, for example 20°, per minute.
19. Method according to any of the preceding patent claims, characterized in that the degree of enlargement

used within the said range is determined as a function of the compaction pressure used, and in that a low degree of enlargement is used for a low compaction pressure, and vice versa.

- 5 20. Method according to any of the preceding patent claims, characterized in that the shrinkage/sintering effects a shrinkage which is slightly below the chosen degree of enlargement.
21. Method according to any of the preceding patent  
10 claims, characterized in that the product is produced with a degree of precision of about 20  $\mu\text{m}$  with respect to its inner and/or outer shapes.
22. Method according to any of the preceding patent  
15 claims, characterized in that the product has a wall thickness (t) within the range of 400 to 600  $\mu\text{m}$  and/or a gap size between inner shape/inner surface and an opposite surface of the dental component (tooth replacement part, implant, spacer or other attachment part) of 100 to 400  $\mu\text{m}$ .
- 20 23. Product intended as a component in a dental application or other application in the human body, where it cooperates with members (O) in the form of implants, attachment parts for implants, bones, for example dentine, tooth remnants, etc, and made from  
25 worked or sintered powder material (1'''), characterized in that the powder material consists of or comprises metal powder material (1'') deformed by compaction and sintered to a porosity of at most about 6 percent by volume, preferably at most 2 to 3 percent  
30 by volume.
24. Product according to Patent Claim 23, characterized in that the compacted and sintered material is homogeneous and ductile.
25. Product according to patent Claim 23 or 24,  
35 characterized in that it has a configuration which has essentially a cap-like character and preferably is conically tapering from its free end.

26. Product according to Patent Claim 23, 24 or 25, characterized in that it is thin-walled and has wall thicknesses within the range of 400 to 600  $\mu\text{m}$ .
27. Product according to any of the preceding  
5 patent claims, characterized in that it has a precision fit on its inner and/or outer shapes of about 20  $\mu\text{m}$ .
28. Product according to any of Patent Claims 23 to 27, characterized in that it forms a self-supporting structure whose strength properties correspond to those  
10 of a conventional product for a dental application or other application in the human body.
29. Product according to any of Patent Claims 23 to 29, characterized in that its inner shape is designed so that it can be applied or arranged with an  
15 intermediate gap (cf. a) of 100 to 400  $\mu\text{m}$ .
30. Product according to any of Patent Claims 23 to 29, characterized in that it has a degree of compaction which allows it to be worked by cutting tools, for example turning or milling, when producing the outer  
20 shape.
31. Product according to any of Patent Claims 23 to 30, characterized in that the powder material is titanium powder.
32. Product according to any of Patent Claims 23 to  
25 30, characterized in that the powder material is gold alloy or steel powder.
33. Use of a product (15, 16, 17, 18) intended for a dental application or other application in the human body, where the product cooperates with biocompatible  
30 or structural members or materials, such as teeth, tooth parts, bones, for example dentine, implants, attachment parts for implants, etc., and comprises or consists of compressed and sintered powder material, characterized in that metal powder (1) which is  
35 compacted and sintered to a porosity of at most about 6 percent by volume, preferably 2 to 3 percent by volume, is used as powder material (1''').
34. Use according to Patent Claim 33, characterized in that titanium powder (1) is used as powder material.

35. Use according to Patent Claim 33, characterized in that gold alloy or steel powder is used as powder material.

36. Use according to Patent Claim 33, 34 or 35,  
5 characterized in that the metal powder or titanium powder (1) is used for producing a cap-like and preferably self-supporting product (1''').

Fig. 1

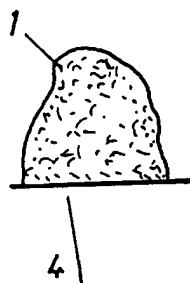


Fig. 2

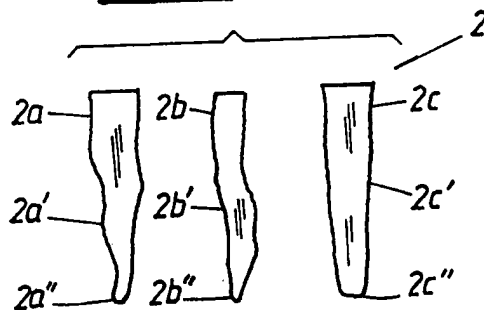


Fig. 3

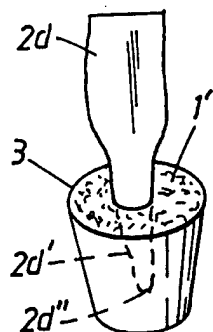


Fig. 4

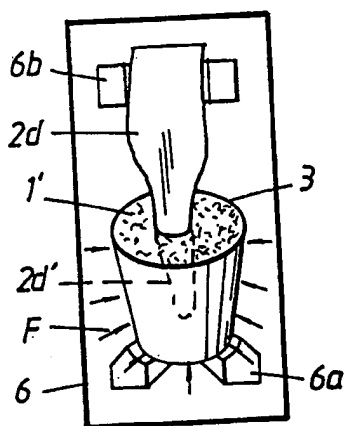


Fig. 5

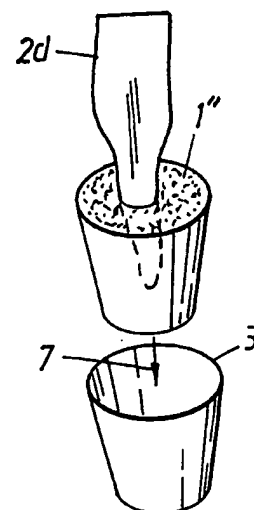
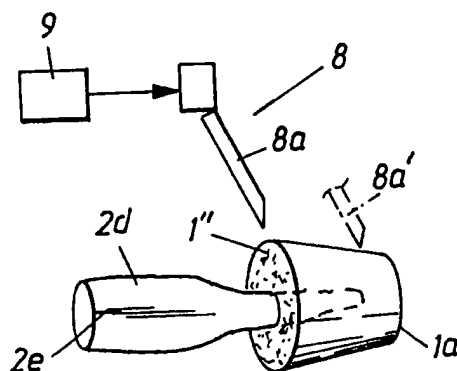


Fig. 6



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Fig. 7

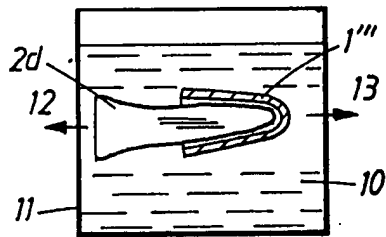


Fig. 8

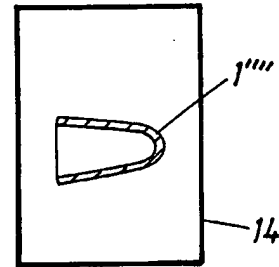


Fig. 9

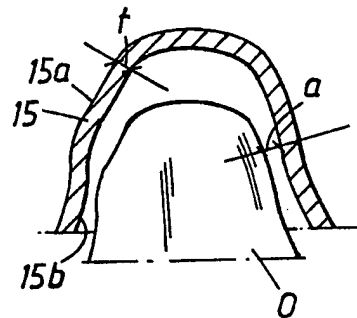


Fig. 10

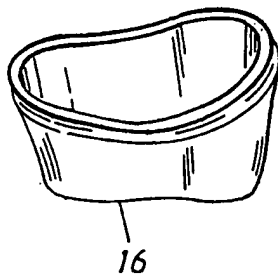


Fig. 11

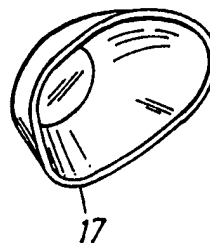
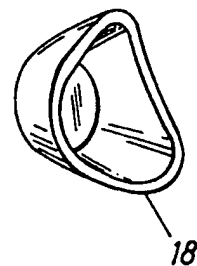


Fig. 12





# INTERNATIONAL SEARCH REPORT

International Application No.

PCT/SE 99/01559

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A61C 5/10

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: A61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0384907 A1 (NOBELPHARMA AB), 29 August 1990 (29.08.90)  --	1-36
A	EP 0384908 A2 (NOBELPHARMA AB), 29 August 1990 (29.08.90)  --	1-36
A	EP 0389461 A1 (SANDVIK AKTIEBOLAG), 26 Sept 1990 (26.09.90)  -- -----	1-36

☐

Further documents are listed in the continuation of Box C.

☒

See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

20 January 2000

Date of mailing of the international search report

29 -01- 2000

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International Application No.

PCT/SE 99/01559

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